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Experimental Study on the Strength Properties of by the Partial Replacement of Cement in Concrete

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Abstract

The main objective of this experimental study is to reduce the percentage of the cement in the concrete. As the basic material used in the field of construction is cement, the increase in the cost of cement results in environmental and expenditure problems. There are many materials that are capable of enhancing and altering its strength characteristics. This study primarily focuses on the influence of strength of concrete which is prepared by using materials like Silica Fume(SF) and Ground Granulated Blast Furnace Slag(GGBS) . The main objective of this study is to partially replace the cement content with Silica Fume(SF) of 3,5,7% and GGBS at 5,10,15% by the weight of cement. The mix design of M40is adopted and the replacements are made in it. Finally, the concrete specimens are cured and are subjected to strength tests and the results are analyzed.

Keywords*: - Concrete, GGBS , IS: 10262-2009, Silica fume, Strength properties.*

INTRODUCTION

The concrete is the important mixture which makes a building to withstand for a longer period of time. It is the primary material in the field of construction. Ordinary Portland cement is the commonly used building material throughout the world. The production of the cement causes environmental problems by which is caused by the emission of carbondioxide into the environment. Further the greatest Challenge for the construction industry is to serve the need of human society, namely the protection of the environment

and meeting the infrastructure requirements of growing population by maintaining the reduced content of carbon dioxide . The above experimental investigation is carried out in the optimization of a concrete system. Compressive, tensile and flexural strength of partially replaced cement in concrete mix and which these strengths are obtained at period of 7 & 28 days for various replacements of GGBS and Silica Fume mixes are investigated.

Ground Granulated Blast Furnace Slag (GGBS) is a recyclable material is a byproduct of iron and steel slag. The slag is subjected to steam in order to get a dried product. Later it is reduced to the required fineness. Blast Furnace Slag is defined as the non- metallic product which consists of calcium silicates and other bases that are developed in molten state simultaneously with iron in a blast furnace. The main use of GGBS in the field of construction is to increase the strength of the concrete and it is also used for the soil stabilization.

Silica Fume is also known as Micro Silica. Micro silica is produced in the electric arc furnaces as a byproduct from the production of elemental silicon or alloys containing silicon. SF is good at the improvisation of the mechanical properties of the concrete. The rate of hydration of silica fume is high when compared to GGBS. So as to balance the rate of hydration in cement the material which is added along with GGBS is silica fume.

OBJECTIVES:

- To conclude the mix design proportion by GGBS and SF with fiber to attain the desire requirements of the concrete.
- To find out the maximum percentage of fiber that can be added extra to the concrete to attain a desired needs.
- To examine the strength properties of concrete (i.e) compressive strength, splitting tensile strength, flexure strength of the concrete.

MATERIALS :

Cement:

The cement used for the experimental study is 53 grade and the physical tests were conducted for cement before it has been used.

Fine aggregate:

In this the fine aggregate used are locally accessible material conforming to which graded aggregate of nominal size 12.5 mm, 20mm as per IS 383:1970 IS used.

The used fine aggregate is naturally available and it is sieved using 4.75mm size.

Coarse aggregate:

The aggregate which is locally available with nominal size of 20mm according to the specifications as per code IS 383:1970 is used.

Water:

The water which is used naturally available tap water or portable water without containing any chemicals or salts. The water cement ratio which is used for the mixing of concrete is taken according to IS :456-2000.

GGBS:

Ground Granulated Blast-Furnace Slag is defined as "non-metallic product combination of calcium silicates and further bases that is urbanized into a molten state repeatedly with iron in a blast furnace."

Silica fume:

SF is good at the improvisation of the mechanical properties of the concrete. The rate of hydration of silica fume is high when compared to GGBS. So as to balance the rate of hydration in cement the material which is added along with GGBS is silica fume.

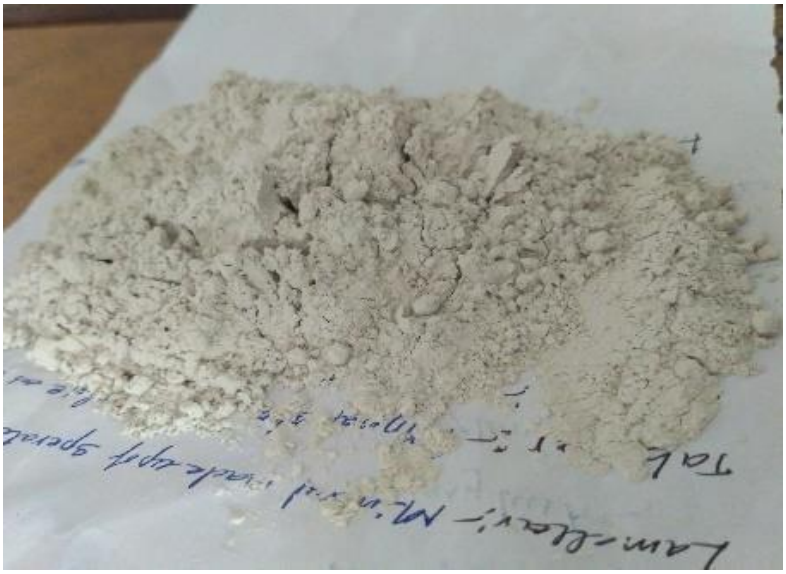
Table-1: Properties of Ground Granulated Blast Furnace Slag

Compound	Percentage
Calcium oxide	40%-50%
Silicon dioxide	10%-19%
Magnesium oxide	5%-10%
Manganese oxide	5%-8%
Aluminum oxide	1%-3%
Iron oxide	10%-40%

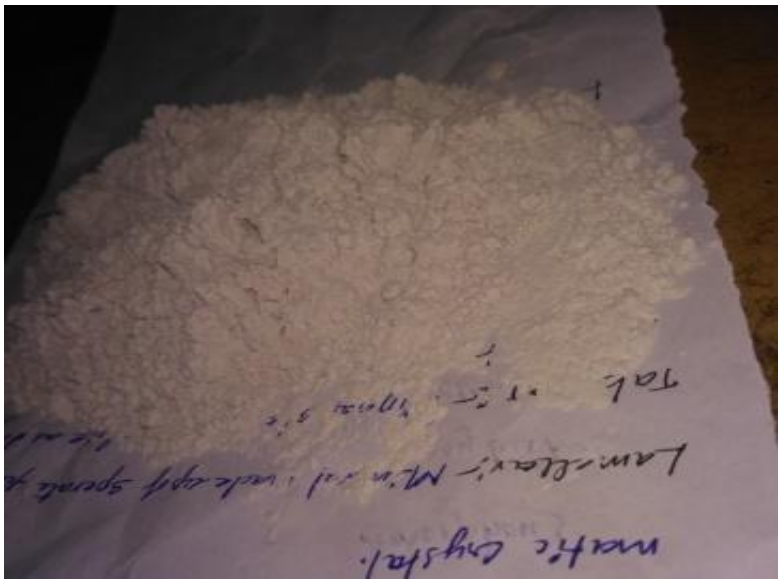
Table-2: Properties of Silica Fume

Compound	Percentage
Aluminum oxide	0.1%
Magnesium oxide	0.6%

Iron oxide	0.1%
Calcium oxide	0.2%
Sulphate	0.1%
Sodium oxide	0.4%



GGBS in powder form



Silica fume in powder form

METHODOLOGY:

The mix design adopted is M40 (Design Mix) which is estimated according to the code IS: 10262-2009. The proportions for this mix is (1: 0.25: 0.5) and the adopted water cement ratio as 0.5.

The proportions of GGBS and SF which are partially replaced in place of the cement are 5% GGBS + 3%Silica Fume, 10% GGBS+ 5% Silica Fume, 15% GGBS+ 7%Silica Fume. The mixing which is adopted is hand mixing. The concrete is mixed and are casted in the form of cubes and prisms. Curing is done after the hardening process completed for a period of 28 days. The curing which is generally adopted is pond curing. After specified period of curing the tests for the specimens are conducted.

Table-3: Proportions for Mix Designs

Mix Design	Proportions
Nominal Concrete	1:0.25:0.5
5% GGBS +3%Silica fume	1:3.12:1.90:0.05:0.03
10 % GGBS+ 5% Silica fume	1:3.33:2.04:0.12:0.06
15% GGBS+ 7%Silica fume	1:3.57:2.18:0.19:0.09

Table 4: Compositions for Various Proportions

Description	Cement	Fine Aggregate	Coarse Aggregate	GGBS	Silica Fume	Water
Nominal Concrete	3.9kg	7.14kg	11.6kg	-	-	1.97 lit
5%GGBS+3%SF	3.67kg	6.93kg	11.3kg	179g	118g	1.85 lit
10%GGBS+5% SF	3.39kg	6.83kg	11.1kg	394g	197g	1.67 lit
15%GGBS+7%SF	3.10kg	6.72kg	10.7kg	591g	276g	1.53it

RESULTS AND DISCUSSIONS:

The results of the compressive strength, splitting tensile strength and flexural strength of various concrete mixes containing different proportions of GGBS and Silica Fume are mentioned earlier. The tests conducted according to the IS code specification as mentioned above . Results were compared and checked for compressive, splitting tensile and flexural strength.

Table-6: Results for Properties of Cement

Physical Properties		
Fineness (m^2/kg)	225 (minimum)	320
Soundness(mm)		
Le-chatlier method	10(mm) maximum	1.0
Autoclave(%)	0.8 (maximum)	0.05
Setting Time		
Initial (minimum)	30 minutes	160+or-20
Final (maximum)	600 minutes	260+or-20

Table-7: Results for Slump cone test

Nominal mix (%replacement)	**Value**
0%	102mm
5%GGBS&3% SF	103mm
10%GGBS&5% SF	103mm
15%GGBS& 7%SF	103mm

Table-8: Slump Cone Ranges

Slump Range	Workability
10-40mm	Low Workability
50-90mm	Medium Workability
>100mm	High Workability

Results of Compressive Strength Test:

The compressive strength of concrete specimens which are casted with different proportions of GGBS and Silica Fume. Totally 18 cubes were casted. Curing is done for 7 and 28 days in normal water for gaining required maximum strength.

Table 9: Results for Compressive Strength of Cubes

Description	7 Days	28 Days
Nominal concrete	25.52KN/m^2	43.17 KN/m^2
5%GGBS+3%SF	25.52 KN/m^2	36.65 KN/m^2
10%GGBS+5%SF	31.49 KN/m^2	45.90 KN/m^2
15%GGBS+7%SF	37.60 KN/m^2	58.53 KN/m^2

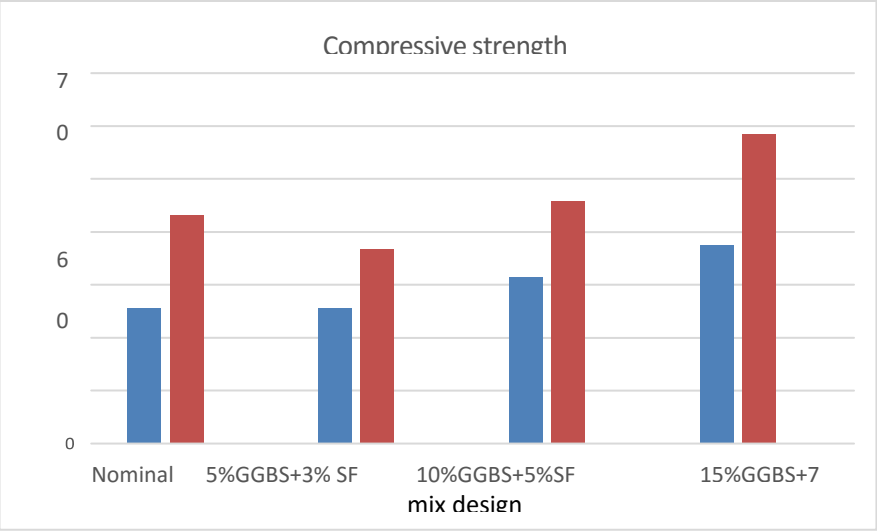


Figure 1 : Bar Chart showing compressive strength of cubes between Normal Concrete vs. combination GGBS AND SF.

Results of Split Tensile Test of Cylinders:

In order to study split tensile strength of GGBS and SF replaced concretes, different proportion of SF and GGBS were prepared. Totally 30 cylinders were casted. Curing is done for 7 and 28 days in normal water to conduct the test for splitting tensile strength. Therefore the results listed in Table below, which are obtained at 28-days strength of all different mix proportions is varied.

Table 10:Results for Splitting Tensile Strength of Cylinders

Description	7 Days	28 Days
Nominal concrete	4.8KN/m2	5.9KN/m2
5%GGBS+3%SF	5.2KN/m2	6.4KN/m2
10%GGBS+5%SF	6.4KN/m2	7.4KN/m2
15%GGBS+7%SF	6.6KN/m2	7.8KN/m2

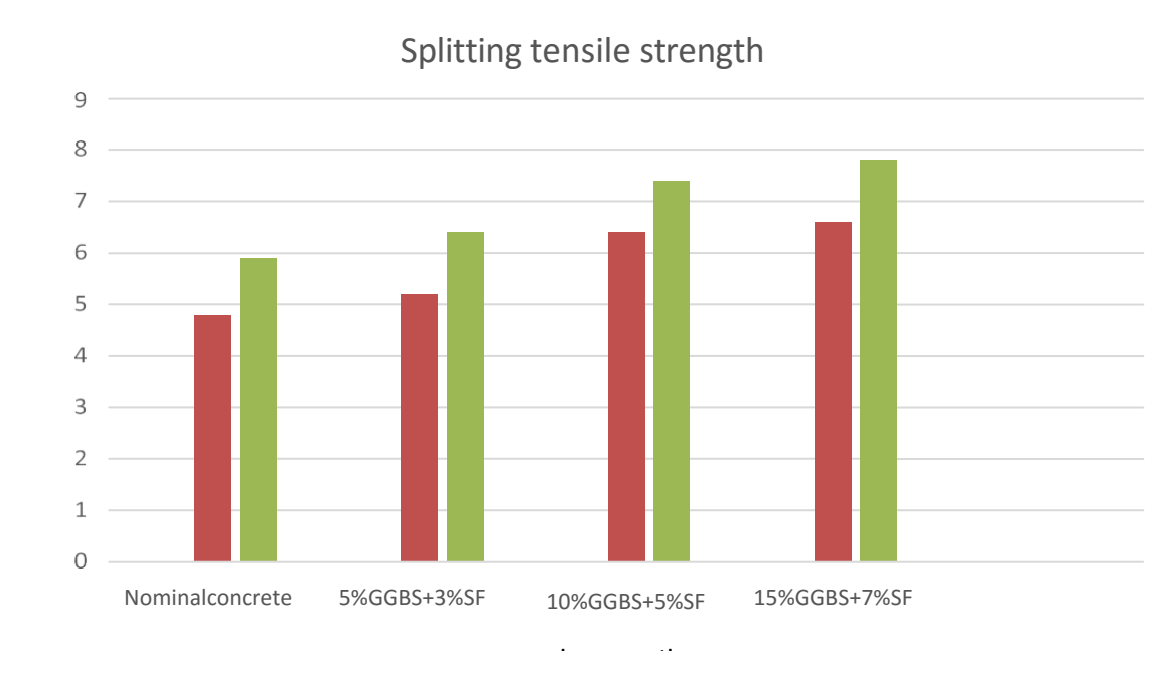


Figure 2: Bar Chart showing splitting tensile strength of strength between Normal Concrete vs. combination GGBS AND SF.

CONCLUSIONS:

The performance of GGBS and Silica Fume concrete and the strengths obtained is compared with nominal or conventional concrete of design strength for M40 grade. The following are the conclusions are as follows:

a. The strength obtained from GGBS and Silica Fume concrete is more when compared to the strength obtained from nominal concrete.

b. 15% increase in compressive strength of concrete for 7 and 28 days when cement is replaced by 20%GGBS and 6%Silica Fume.

c. Up to 30%GGBS and 10%Silica Fume can be replaced with cement during production of concrete.

d. There is a decrease in compressive strength gradually by further excess addition of GGBS and silica fume.

e. The Workability of concrete increases by addition of GGBS and Silica Fume.

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